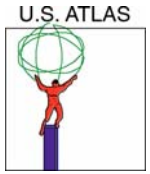


Status of the LHC Program

A Presentation to HEPAP

by

Abe Seiden

April 2004

Outline of Talk

Physics
- First major step in energy in 20 years.

Status of Construction
- 90% complete, large objects done. Preparation of collider halls going well.

Status of LHC Machine
- Well into magnet construction, beginning to deal with installation in tunnel.

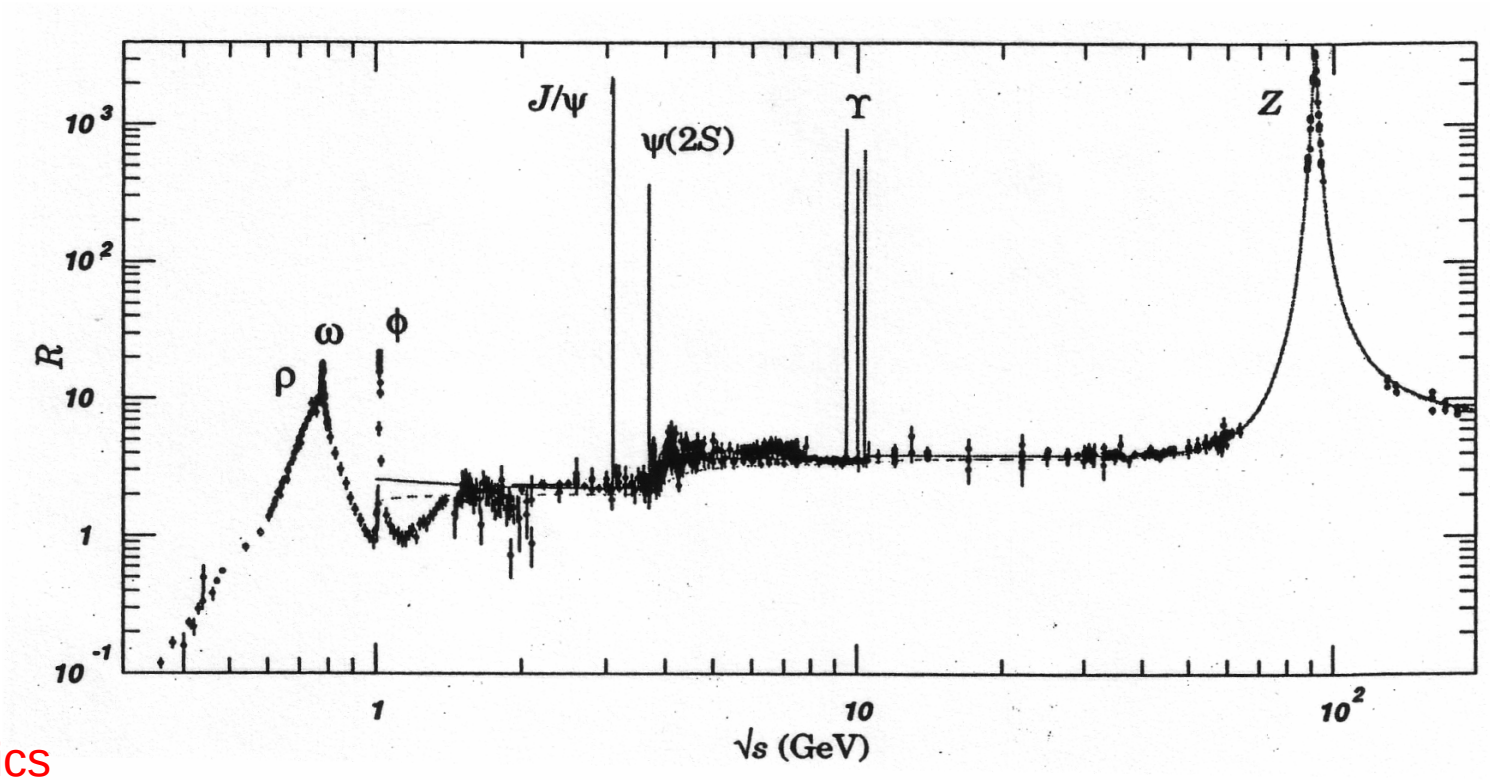
Research Program
- Significant recent perturbations regarding funding, still under discussion.

Base Program Issues
- Readiness for Physics is critical issue for the future.

I will not be covering the very significant U.S. contributions to the machine.

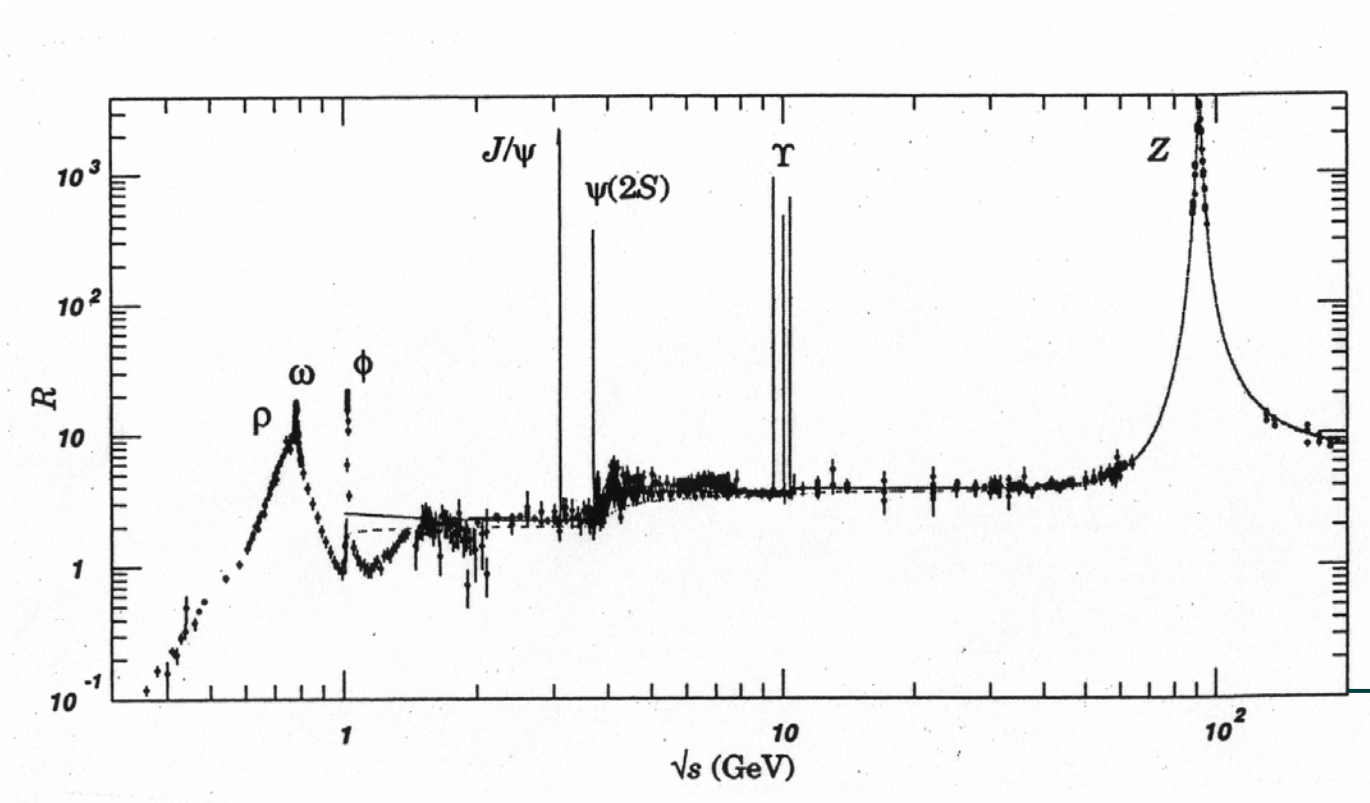
LHC and the Energy Frontier

LHC is our first major step in about 20 years



Physics Initiated	1960's	1970's	1980's

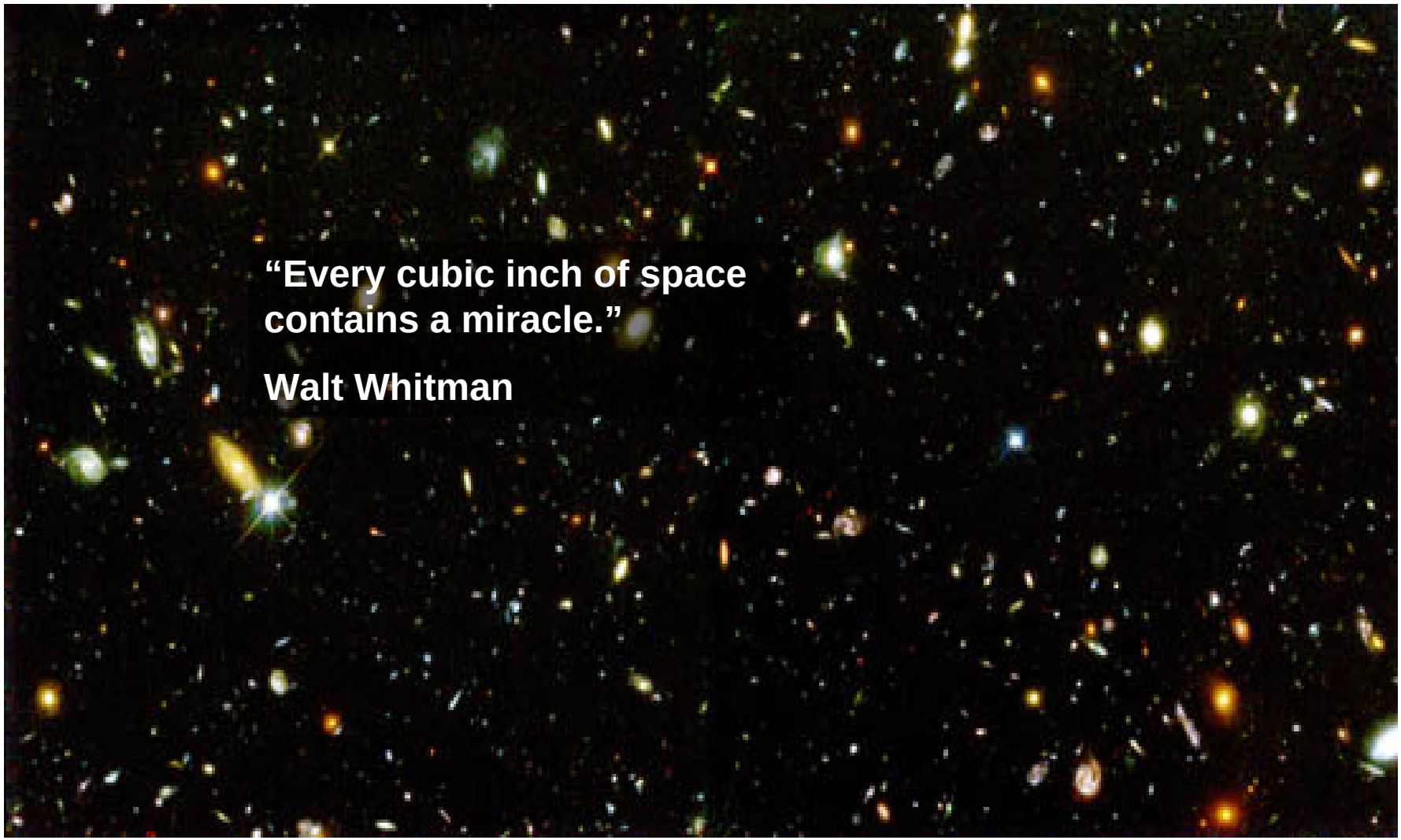
LHC and the Energy Frontier



1 TeV Scale ??

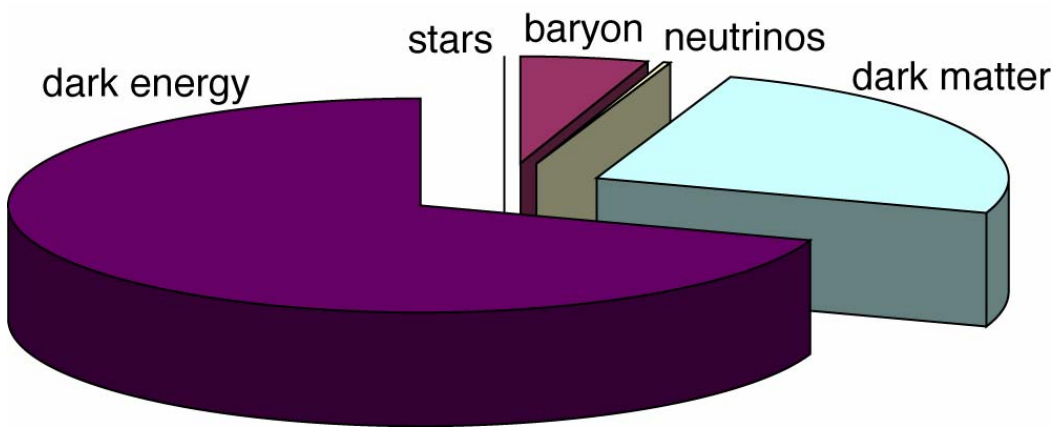
TeV Scale: Origin of electroweak symmetry breaking and the values for many of the parameters measured at lower energy.

The Vacuum



Many Mysteries

Whitman's statement seems to be true!



The universe is filled with something called "Dark Energy" which is accelerating its expansion.

It is also filled with something (called the Higgs field) which gives particles mass.

What are these "somethings"? Will we some day see a relation? The underlying mechanism for both phenomena are not understood.

What is the dark matter?

LHC: Hunting for Big Game

We hope to find a more inclusive physical and conceptual basis to explain some of these mysterious phenomena. Extend how we think about matter, energy, space, and time.

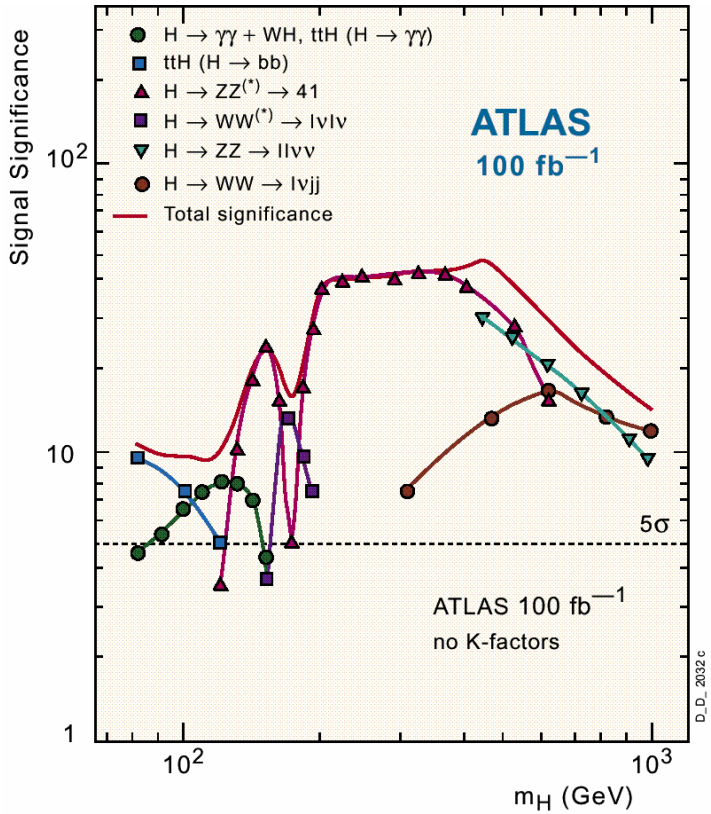
Examples are Supersymmetry or Large Extra Dimensions.

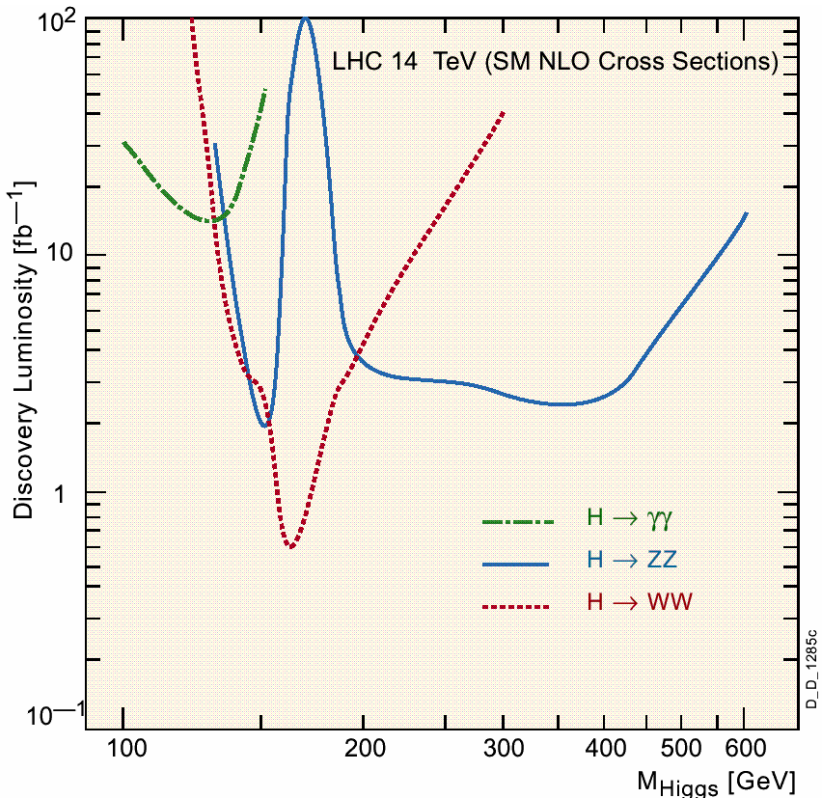
ATLAS and CMS

Two large high-P_t detectors, ATLAS and CMS, are being completed with broad capabilities to explore and reveal the physics at the TeV scale.

A typical benchmark is the discovery capability for the Standard Model Higgs particle that accompanies electroweak symmetry breaking and the Higgs field.

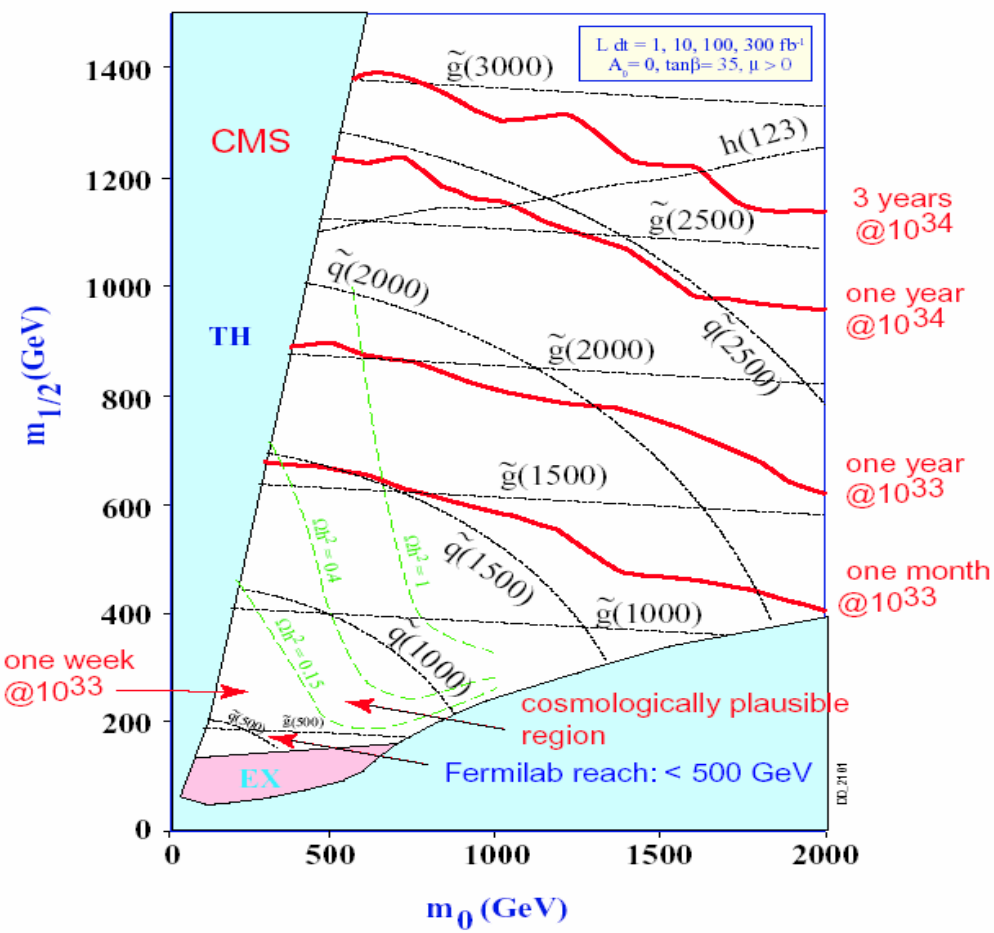
U.S. Groups need to be ready to search for Higgs on Day 1





There are indications the Higgs is light, and groups wishing to pursue this exciting quest must be ready at LHC turn-on. We will discover the Higgs or something equally exciting. We will probably discover it quickly – at 1/10 the machine design luminosity.

SUSY Reach



The LHC should be able to establish the existence of SUSY and open many avenues to study masses and decays of SUSY particles, if m(SUSY) is less than a few TeV.

For example in the SUGRA model, the cosmologically interesting region of the SUSY search will be covered in the first weeks of LHC running, and the 1.5 to 2 TeV mass range for squarks and gluons will be covered within one year at low luminosity.

The U.S. CMS Collaboration

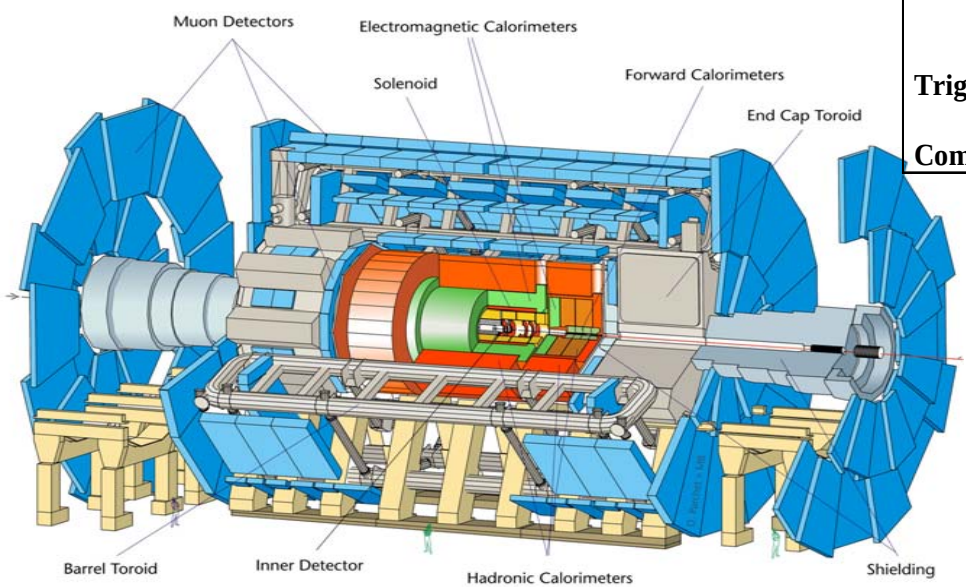
38 Universities and Fermilab

Subsystem	Institutions
Endcap Muon	UC-Davis, UC-Los Angeles, UC-Riverside, Carnegie Mellon, FNAL, Florida, Northeastern, Ohio State, Purdue, Rice, Wisconsin
Hadron Calorimeter	Boston, Fairfield, FNAL, Florida State, Illinois-Chicago, Iowa, Iowa State, Maryland, Minnesota, Mississippi, Nebraska, Northeastern, Notre Dame, Purdue, Rochester
Trigger	UC-Los Angeles, Florida, Rice, Wisconsin
Data Aquisition	UC-San Diego, FNAL, MIT
EM Calorimeter	Caltech, Minnesota, Northeastern, Princeton
Forward Pixels	UC-Davis, FNAL, Johns Hopkins, Mississippi, Northwestern, Purdue, Rutgers
Silicon Tracker	UC-Santa Barbara, FNAL, Kansas, Kansas State, Northwestern, Rochester, Illinois-Chicago

The U.S. ATLAS Collaboration

32 Universities plus
BNL, LBNL and ANL

Subsystem	Institutions
Silicon	UC-Berkeley/LBNL, UC-Santa Cruz, Iowa State, New Mexico, Ohio State, Oklahoma, SUNY-Albany, Wisconsin
TRT	Duke, Hampton, Indiana, Yale, Pennsylvania
Liquid-Argon Calorimeter	Arizona, BNL, Columbia, Pittsburgh, Rochester, Southern Methodist U., SUNY-Stony Brook
Tile Calorimeter	ANL, Chicago, Illinois-Champaign/Urbana, Michigan State, UT-Arlington
Muon Spectrometer	Boston, BNL, Brandeis, Harvard, MIT, Michigan, Northern Illinois, SUNY-Stony Brook, Tufts, UC-Irvine, Washington
Trigger and DAQ	ANL, UC-Irvine, Michigan State, Wisconsin
Common Projects	All institutions



ATLAS underground assembly (UX15)

UX15 infrastructure and detector support system installed

First Calorimeter detector module moved underground

Support system ready for detector installation

ATLAS detector components assembly

Solenoid in front of LAr Barrel Calorimeter ready for integration, test in Mar 04

Tile Barrel Calorimeter assembled on the surface and ready for installation

Barrel Toroid assembly at CERN

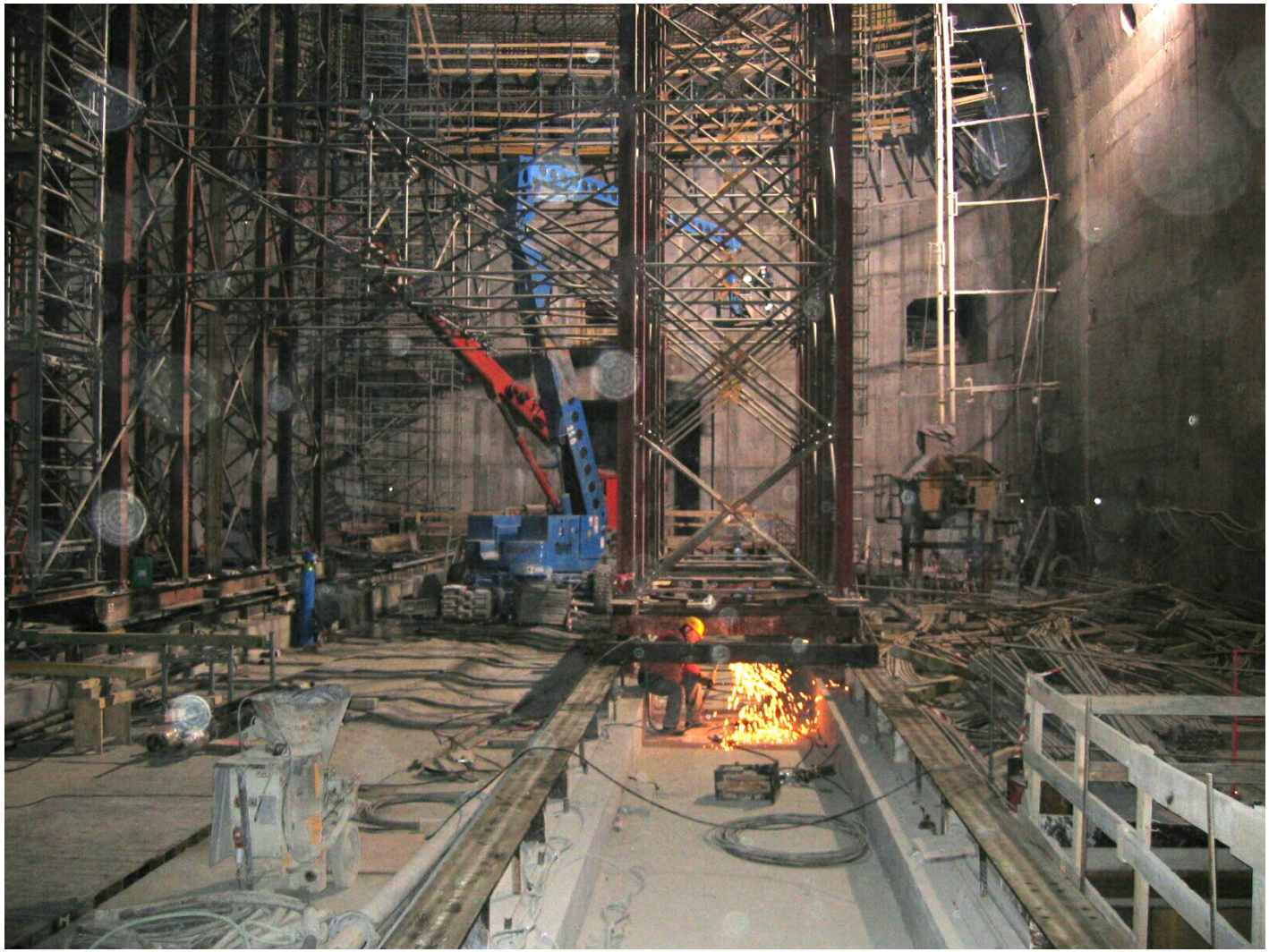
Silicon tracker macro assembly at RAL

CMS: HCAL - HE and HB at SX5

Much of US CMS detector effort is complete. Activity now shifts to commissioning, operations and preparation for data taking.

CMS: 1st Coil Module at CERN-SX5

CMS: UX5 March 04



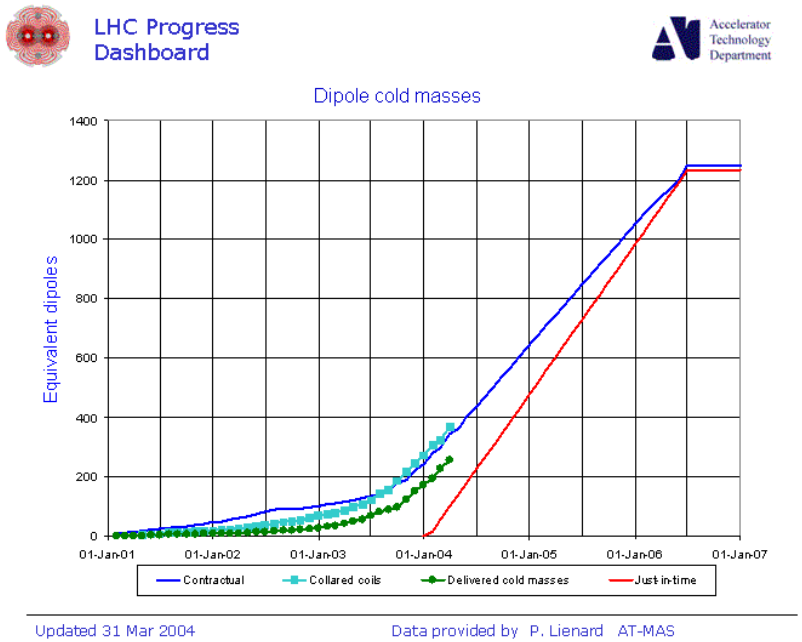
LHC Machine Status

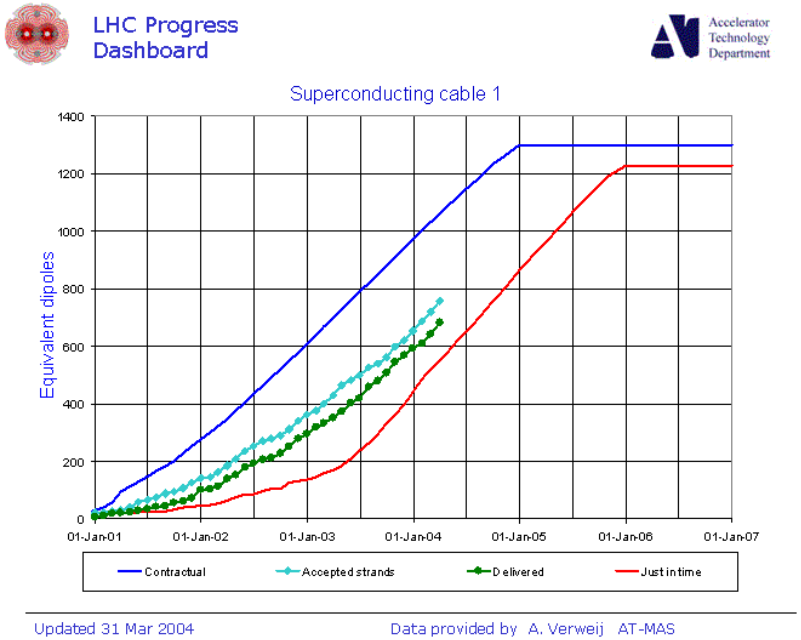
The LHC appears to be on schedule. The new CERN management is strongly committed to the schedule for both accelerator and the experiments.

Magnet progress has been very good and magnet testing appears to be keeping pace with production.

We must hold to our schedule for physicists and computing infrastructure if we want to be major players in LHC physics.

Dipole Magnets

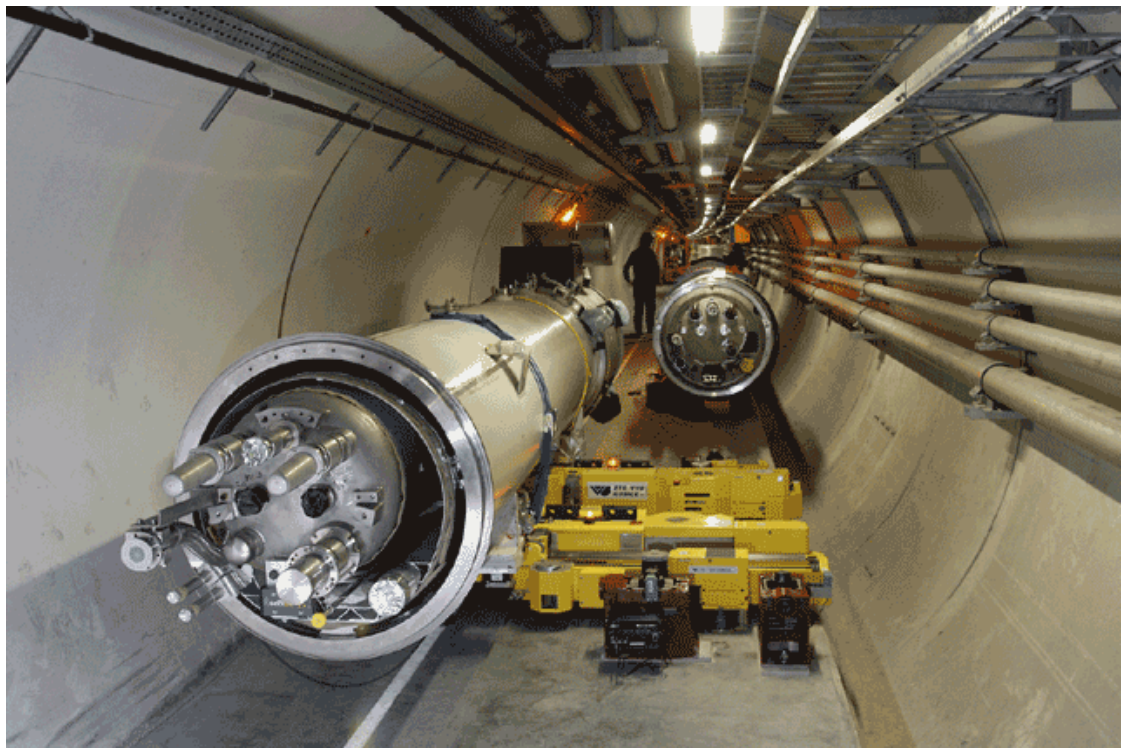




LHC News

LHC Cryomagnets: first steps in the tunnel

A test of the handling system of the LHC cryomagnets was carried on January 27th in sector 1-2, involving the first cryodipole and short straight section (SSS) lowered into the LHC tunnel. The picture was taken during the delicate positioning of a cryomagnet on its jacks, using the transfer equipment set (TES) recently delivered by the Slovak company ZTS VVU Kosice.



LHC Research Program

Composed of several activities required to enable physics at the LHC. Does not support physicists, they are supported by the base program.

Covers activities, which for a U.S. based experiment such as BaBar, are provided by:

(1) Host lab (computing and some operational support).

(2) Common fund (computing professionals and consumables).

(3) Collaborating institutes (technical personnel for maintenance and operations). Philosophy is: “You built it, you maintain it”, although equipment costs might be covered by host lab.

Components of Research Program

(1) Following detector construction and installation of U.S. built components: Pre-operations, maintenance, and operations. Presently about 50% of the research program.

(2) Computing infrastructure:

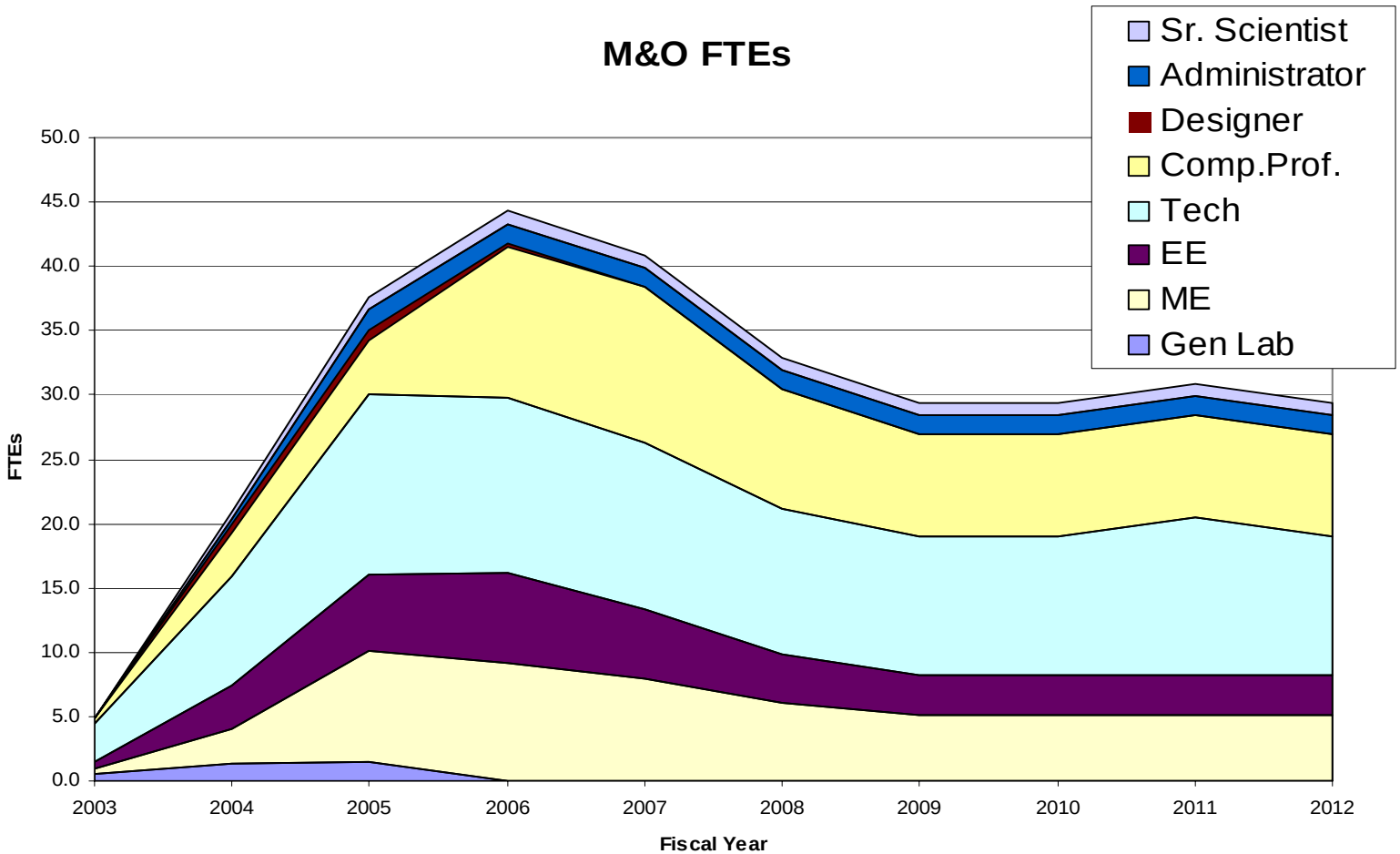
Software to store and retrieve data, support for needed software professionals. Includes the resources required to develop the U.S. computing grid that will enable physics analysis while resident in the U.S. This is expected to eventually become the primary method to do analysis. Presently about 50% of the research program.

(3) Upgrade R&D:

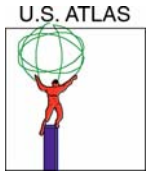
A factor of 10 luminosity increase is expected toward the middle of the next decade. Experiments will require entirely new tracking detectors; also significant impact on data transmission. Expected to ramp up to about 10% of the research program in about 2 years.

Review committees have monitored and scrubbed these programs for the last few years.

The Research Program: M&O



Personnel supported by the U.S. ATLAS Research Program



LHC Computing and Grids

- LHC collaborations are the vanguard of large, distributed scientific communities.
- Distribution of data (Petabytes/year), distributed analysis, 2000+ Collaborators
- Emergence of the first truly global systems for data-intensive processing and analysis.
- In US: alliance with LIGO, Sloan Digital Sky Survey, TeV exp's, biological applications.

Grids Internationally

LHC Computing Grid (LCG): funded mainly by EU.

- US: must be interoperable with LCG

Nordu-grid: small, but effective effort financed by Scandinavian countries

Cross-grid: Eastern European countries (+Ireland+Portugal)

Requires major advances in high-speed networking: will reach 10 gigabits per second data transmission between Caltech and CERN this year (see article in recent CERN Courier).

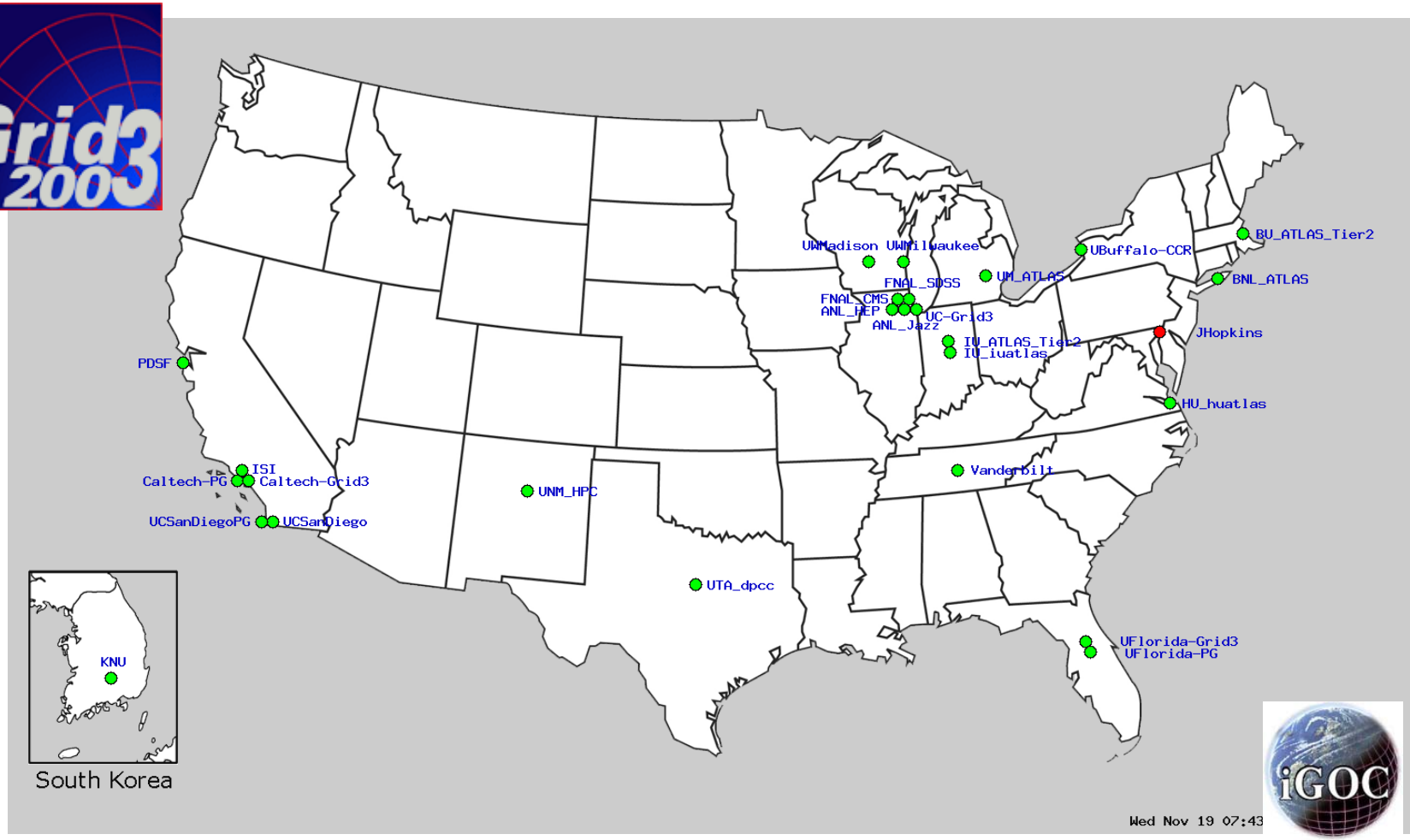
Grid2003

Exercise of linking together US sites into a grid (US LHC experiments, LIGO, Sloan, CDF, DO and others).

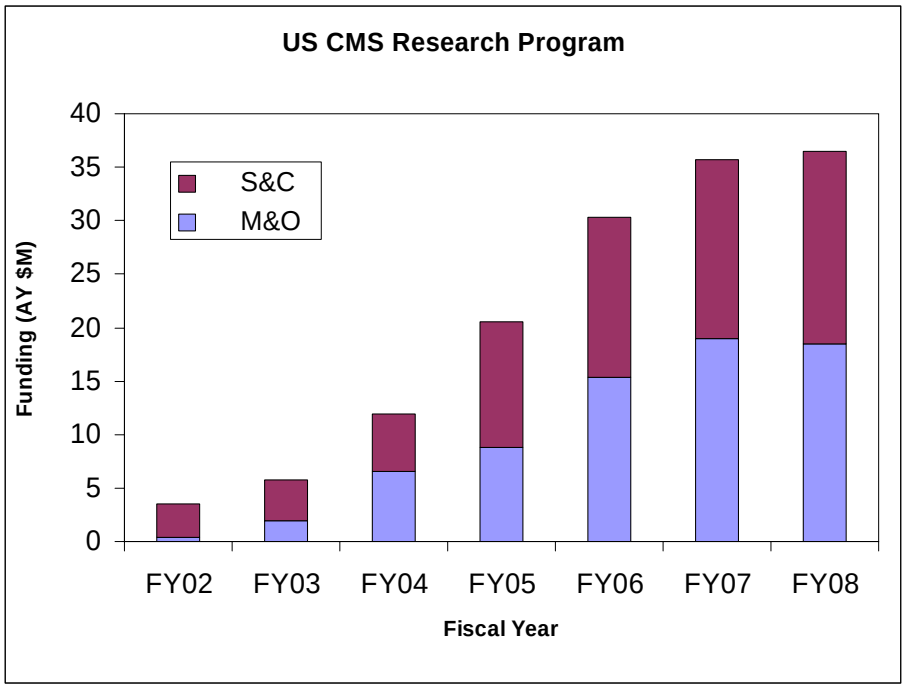
Largest persistent computing grid achieved to date

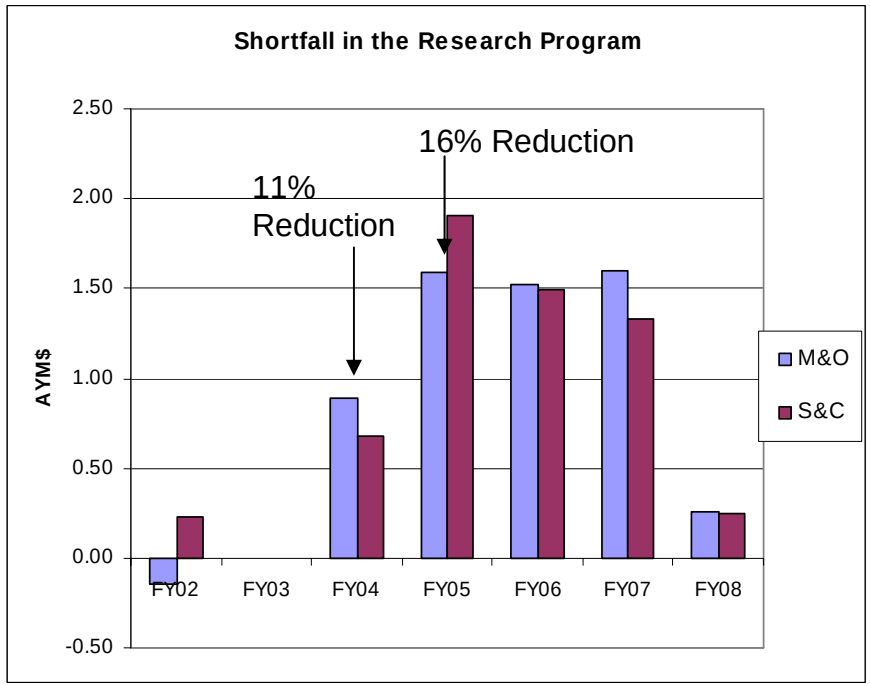
- **28 sites**
- **100's of Terabytes shipped among sites**
- **2800 CPU's**

Grid2003 Status Map (11/19/03)
(http://www.ivdgl.org/grid2003)



The Research Program Split





Feb 2003 Guidance

Feb 2004 Proposed Reductions

Would dramatically slow down physics readiness within the U.S.

Serious Problem! Agency Task Force reassessing situation.

Base Program

Physics activities are funded by the base program.

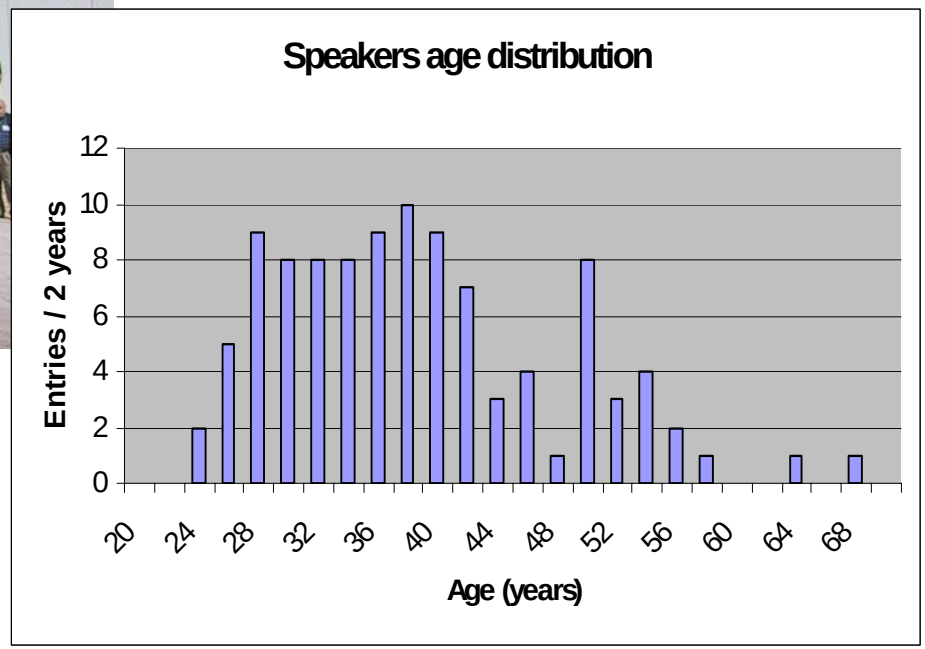
U.S. traditions:

Students get theses by analyzing real data.

Postdocs, typically, get long-term jobs based on accomplishments in “getting out” the physics of a running experiment.

These have implied that the U.S. LHC groups are very short in both postdocs and students. To be among the leaders in doing the physics, we must engage these groups soon. Next year the time frame will be right to match the U.S. traditions for career success.

4th ATLAS Physics Workshop
Athens, May 2003



Speakers age distribution of 103 (of the 104) talks

28 female and 76 male speakers

Base Program

Next year, at this time, we will be about two years from the start of data collection. Need students to start to join the analysis efforts as well as participate in bringing up the detector and learning how it works. This will allow two years to prepare for real physics analysis. Will include learning how the calibrations, data taking, reconstruction, and Monte Carlo analyses are done.

Redirection Plan

The plan to build-up the number of students and postdocs is through redirection.

In 2003 U.S. ATLAS has 233 named “Ph.D.” authors out of 1301 total for ~18%.

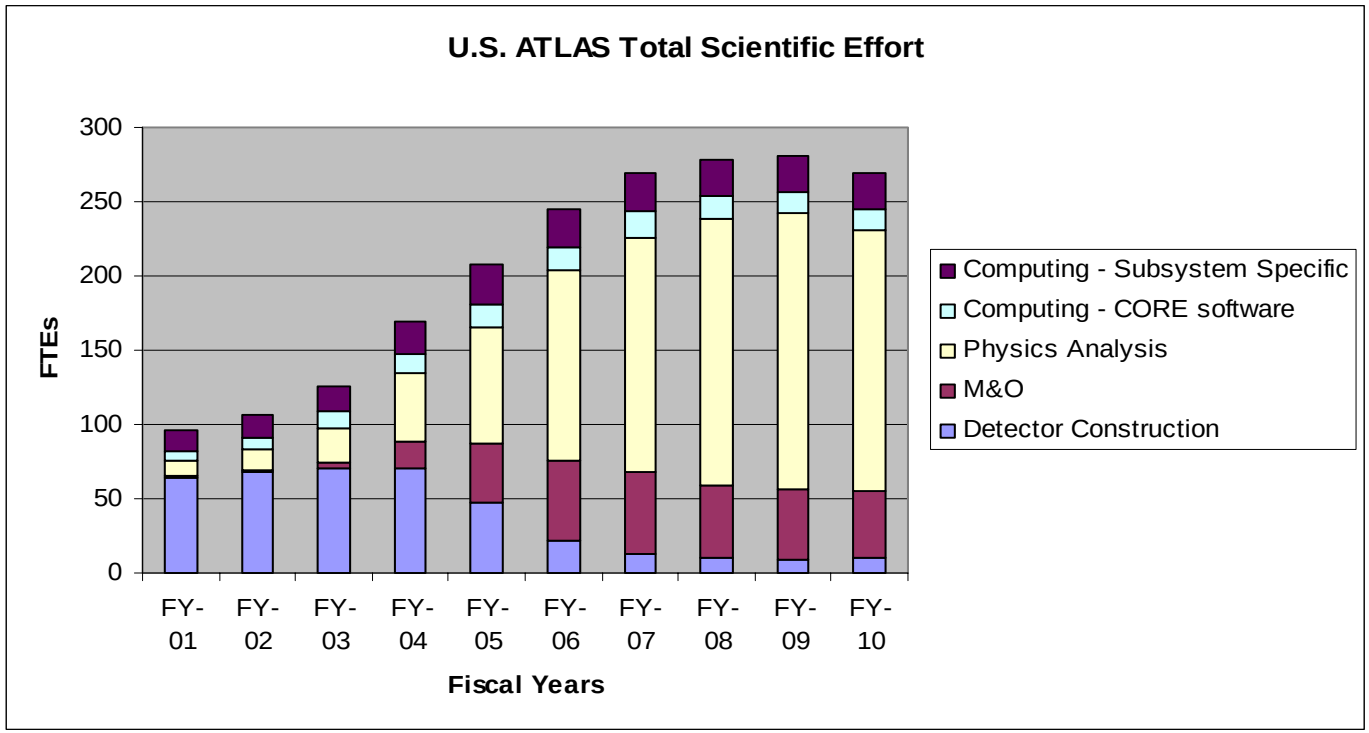
Like in U.S. CMS, this is the largest number of authors of any country with Italy being second with 144 and then CERN with 127, UK 109, Russia+Dubna 102, Germany 99, France 91.

We conducted a survey of every U.S. institution to find their plans for the present and future

We asked them to ensure that any staff increase would come from redirection. This was followed pretty well but may not be 100%.

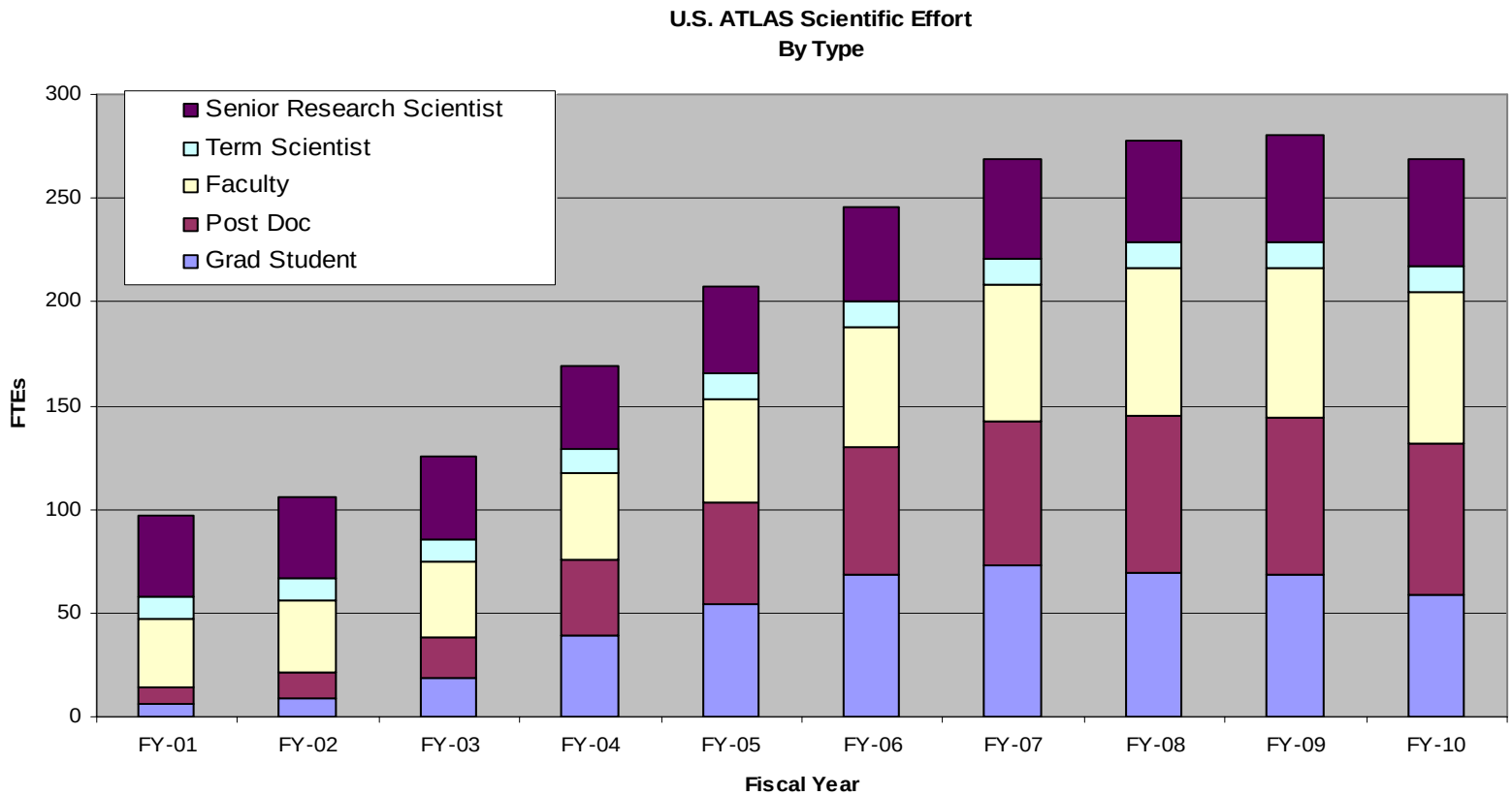
We have found some errors in the survey as indicated by the decline of personnel in FY09 and FY10 – but this gives an indication of the errors ~ 20%.

Total Scientific Personnel by Activity



Scientists are Faculty, Research Scientists, Post Docs, and Graduate Students all supported by the "Base Program"

Breakdown of the "Scientific Effort"



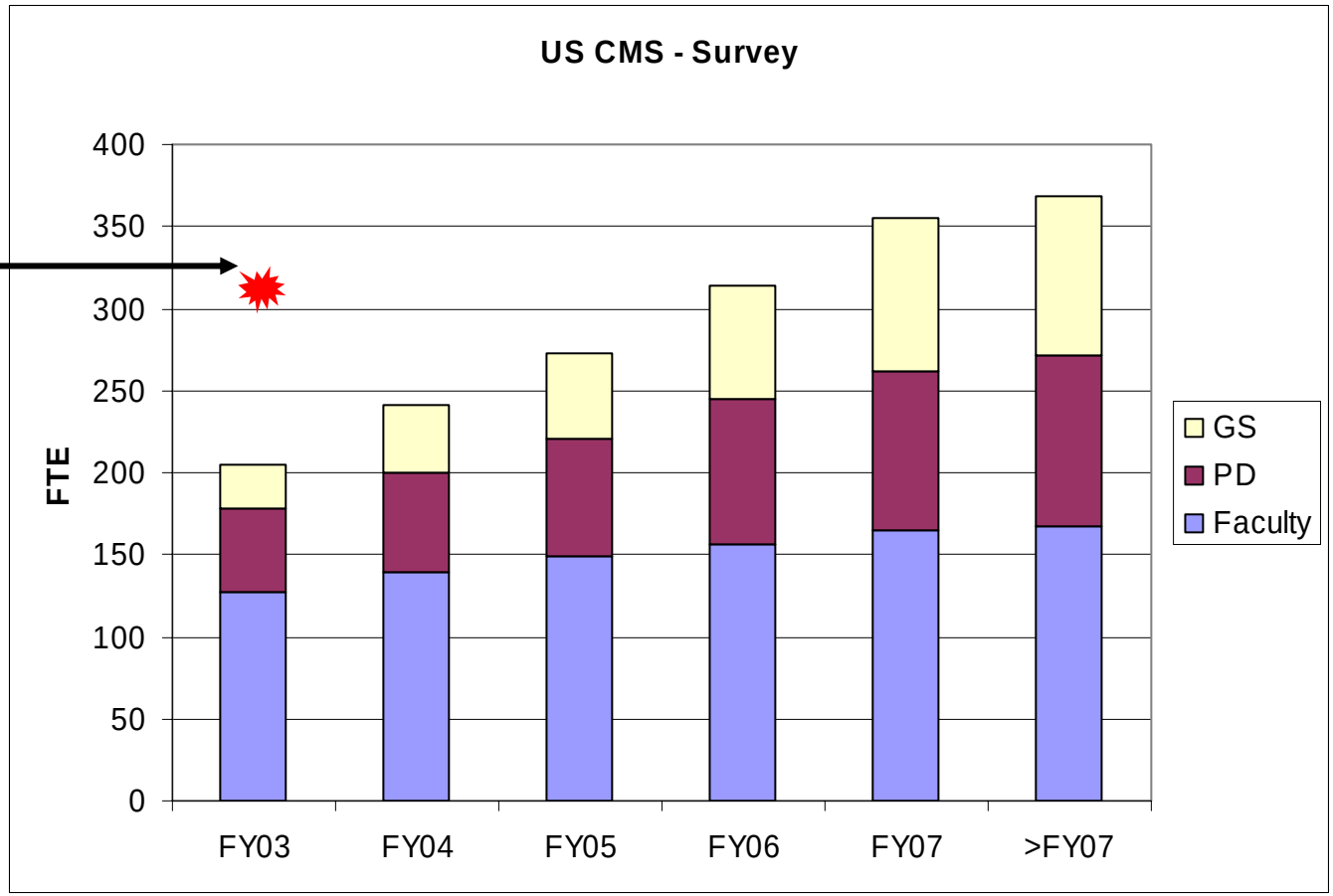
US CMS - Manpower

For 2003:

- US CMS reports 281 physicists (PD + Faculty), of which 42 are at FNAL
- There are also 121 Engineers (EE+ME) plus Computing Professionals (CP)
- There are also 36 graduate students (GS)
- Total (excluding undergraduates and technicians) is 438. Note that this number indicates the level of interest and activity in US CMS not the number of “FTE”.

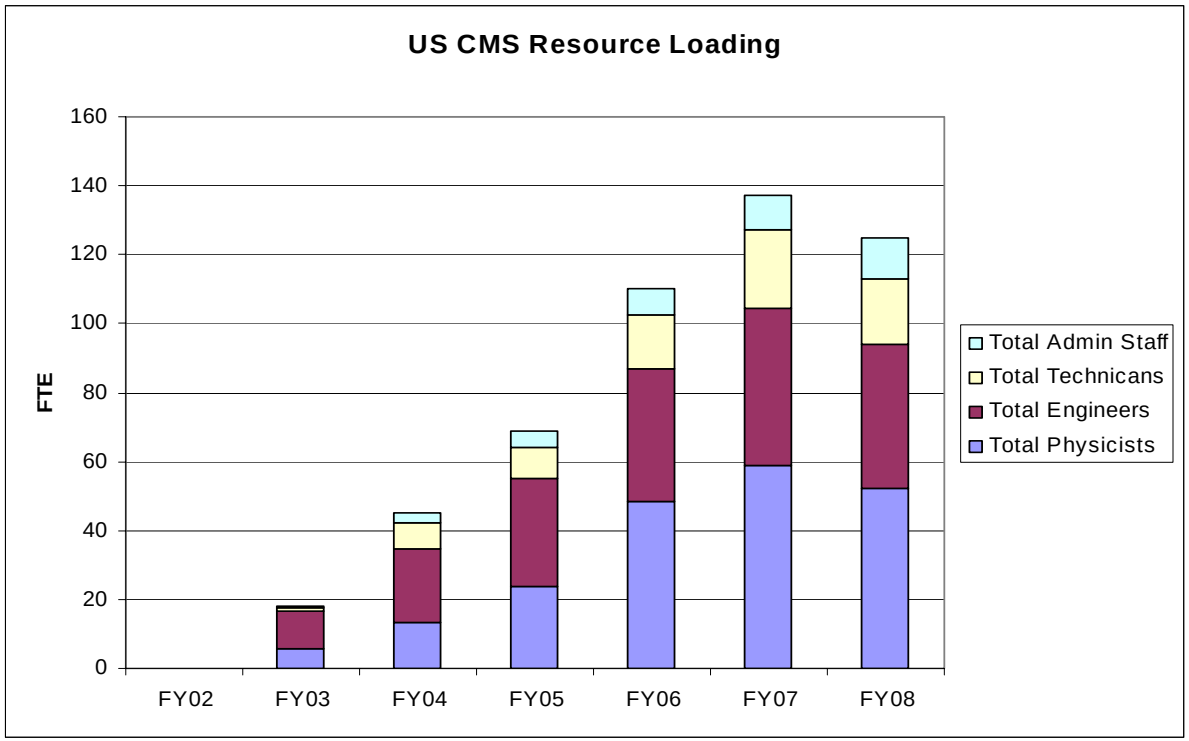
US CMS – Survey of Intent

Total interest, not FTE



US CMS made a survey of intent in regards to redirection of effort. The results were scaled to the fraction of physicists covered by the responses. There is a rapid growth of PD and GS indicated.

US CMS – M&O Review



Resource loaded WBS for US CMS M&O as of 2/04 review. Physicists are Faculty + PD + GS. The units are FTE. The M&O need is ~ 55 FTE.

Redirection Plan

From the point of view of 2010, when the data grid is functioning and the initial reconstruction algorithms are in place, and CDF and DO have completed their analyses, this is a very reasonable approach.

Can it, however, work next year? CDF and DO get most of their data toward the end of their lifetimes, while the LHC experiments need students and postdocs much sooner!

Build-up Physics Effort

Must ensure success for the U.S. physics effort. Requires a successful computing effort within the research program.

Requires that redirection plan works, in particular that we have a significant number of students for each of CMS and ATLAS next year. Will result in a cadre of trained students two years later when data taking starts. If numbers lag, would recommend a temporary initiative to provide physics support while CDF and DO complete their physics program.

LHC Education and Outreach

QuarkNet

REU/RET at CERN (Northeastern/Michigan)

USCMS Fellows

Education and the GRID

Atlas Outreach

- Videos, Brochures, Education Materials

CMS Informal Education

- Portable/handheld particle detectors

Exciting Science

We need to get students excited about science again and involved in classroom research.

To do that, we need to get scientists and teachers working together.

QuarkNet does just that!

QuarkNet

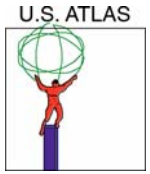
Now in its 6th year.

52 Centers in 25 States and Puerto Rico.

474 participating teachers

208 participating physicist mentors

Embraces much of HEP – 15 different experimental programs, so the reach is well beyond LHC.



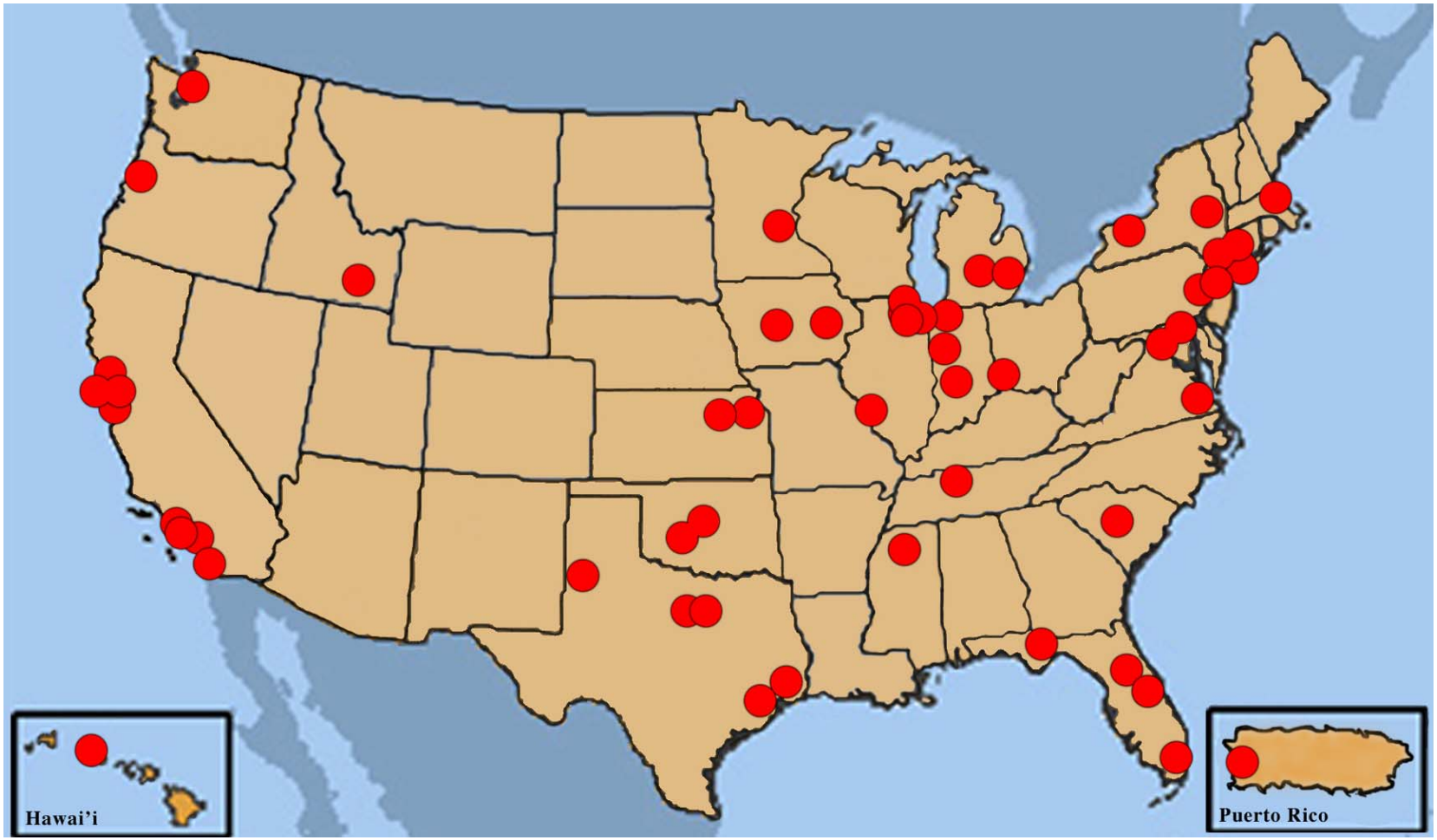
48 Centers (+ 4 in '04)

Argonne National Laboratory
Boston University/Northeastern University
Brookhaven National Laboratory
Columbia University/Nevis Labs
Fermilab
Florida Institute of Technology
Florida International University
Florida State University
Hampton University
Idaho State University
Indiana University
Iowa State University
Johns Hopkins University
Kansas State University
Lawrence Berkeley National Lab
Michigan State University
Notre Dame University

Purdue University
Rice University
Rutgers University
Southern Methodist University
Stanford Linear Accelerator Center
Stanford University
SUNY Albany
SUNY Stony Brook
Texas Tech University
Univ. of California at Los Angeles
Univ. of California at Santa Cruz
University of California at Irvine
University of California at Riverside
University of Chicago
University of Cincinnati
University of Florida
University of Hawai'i
University of Houston

University of Illinois - Chicago
University of Iowa
University of Kansas
University of Maryland
University of Minnesota
University of Mississippi
University of Oklahoma/Langston University
University of Oregon
University of Pennsylvania
University of Pittsburgh
University of Puerto Rico
University of Rochester
University of South Carolina
University of Texas at Arlington
University of Washington
Vanderbilt University
Wayne State University

QuarkNet Centers – 2004



QuarkNet Initiatives FY2004

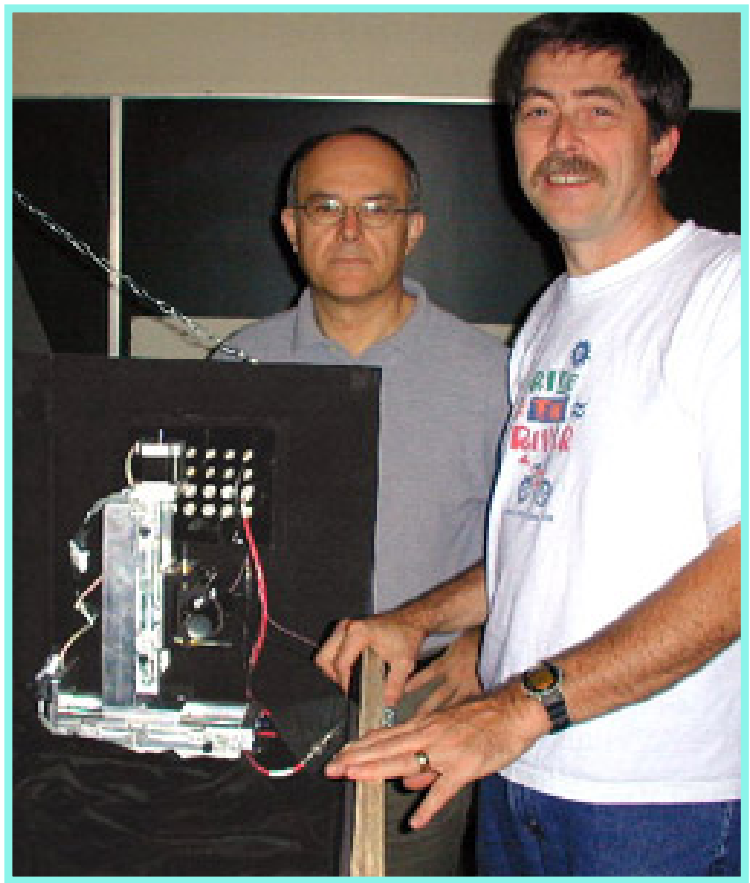
Center enrichment

- **High school student researchers –**
  - 8 week research experience
  - Growth at rate of 24/yr
- **High school teacher researchers –**
  - 8 week research experience
  - Growth at a rate of 6-12/yr

Modeled after pilot program

- 5 year effort, 56 student participants at Notre Dame
- Sponsored in part by USCMS, DØ, and ND

Teacher and Student Researchers



CMS HF ↑ CMS HCAL →

Education and the Grid

The development of Grid computing is essential to the successful implementation of experiments such as CMS and ATLAS.

High school physics classroom research can also benefit, directly, from Grid connectivity.

- **CMS is planning to dedicate a trigger stream to QuarkNet.**
- **Data from beam tests and experiments can be shared.**
- **Data produced/recorded in classrooms or schools can also be shared and analyzed.**

ATLAS Outreach Activities

Public webpages
ATLAS Movie
ATLAS 3D virtual reality animation
New brochure for public and students
ATLAS poster (to be printed)
ATLAS physics poster (to be printed)
Collaboration on CERN's 50th Anniversary
Web "textbook" for students
CDROM
DVD (to be produced)
Webcam of ATLAS cavern
Tours of ATLAS construction areas

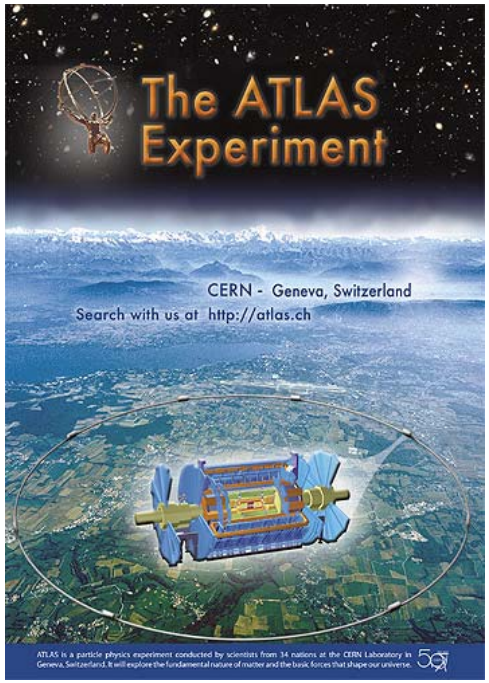
ATLAS Movie

Movie made by ATLAS Experiment's Outreach Committee has won four gold medals at int'l film festivals!

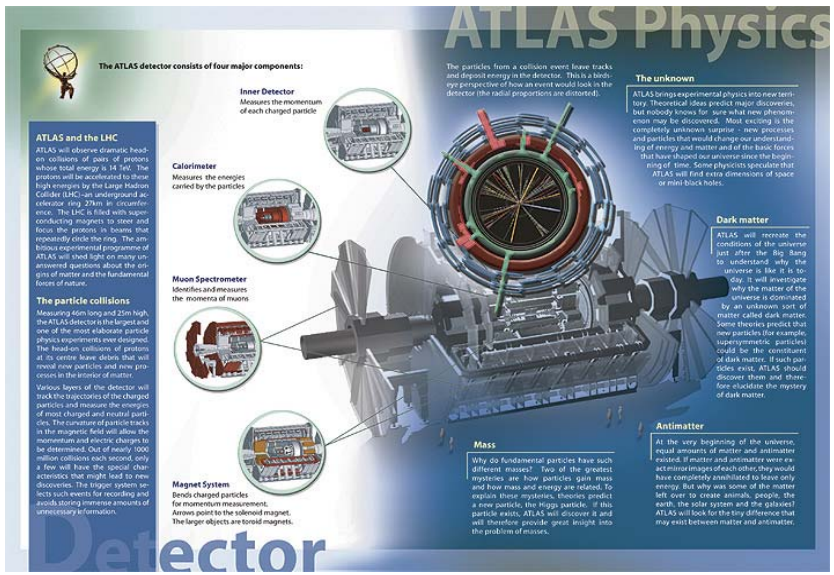
http://atlas.ch/movie

Czech, Dutch, English, French, German, Italian, Japanese, Spanish, Swedish, Chinese

New ATLAS Brochure



Cover



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Back

USCMS Informal Education

Compact, fiber-optic particle detectors to view directly particle interactions or cosmic rays.

- **Currently in operation at:**
  - National Air & Space Museum, Smithsonian, Washington, DC
  - Lederman Science Center, Fermilab
  - CMS and Visitor Gallery, SX5, CERN, Geneva, Switzerland
  - Boston University QuarkNet Center
  - CDMS/MINOS Visitor Center
  - University of Bristol, UK
  - University of Notre Dame QuarkNet Center
- **In preparation for:**
  - University of Wisconsin, Science Museum
  - CROP/Pierre Auger Project